Recommended Practices for CNG Fueling Station Design, Construction and Operation

GRI/NGV-IWG RFP

Project No. 0000000908

Presented at:

NGV TECHNOLOGY FORUM

TECHNICAL COMMITTEE MEETING

January 28, 2003

Dallas, Texas

Prepared by:

Marathon Technical Services

P.O. Box 318, 6 Venus Crescent
Heidelberg, Ontario,Canada N0B 1Y0
Phone 519-699-9250
Fax 519-699-9255
e-mail: radams@marathontech.ca

CNG Station Best Practices- Purpose and scope of project

- Review current industry Best Practices related to CNG station design, construction, operation and maintenance. Compile these for use by the industry.
- Provide a CNG primer manual and a Code Official's handbook and video to assist Code Officials to better understand permitting requirements.

CNG Station Best Practices- Revised deliverables

Marathon has discussed the deliverables with GTI as we proceeded and we have revised the format of the deliverables:

- **All information will be CD and or Web based.**
- **This format allows the information to be more interactive in nature.**
- **Production and distribution costs and time are reduced.**
- **Updates are easier, faster to produce and distribute.**
- **It is likely that this format will be more useful and more used than paper reports and VHS tapes.**

CNG Station Best Practices- Preview of deliverables

Content and format of the Products

- **Preview of CNG 101 - CNG Primer**
- **Preview of CNG 201 - Code Handbook**
- **Preview of Bus-to-Bus Fueling Procedure (developed under separate contract)**
- **Preview of Station Equipment Selection & Budgeting.**

CNG Station Best Practices- Suggested "Best Practices"

Other Best Practice topics/Case Studies - What are "Best Practices"

Examples:

- Fueling procedure/Temperature compensation
- Oil carryover - PAG oils
- Oil carryover - Proper filtration design, maintenance
- Fail Safe Control Systems/Gas Detection
- Station flow optimization, gas flow, pipe sizing, etc.
- Station redundancy.
- Station layout - dispenser location, noise reduction, etc.
- Isolation and Blowdown Design and procedures
- Industry Incidents - lessons learned
- Other - Brainstorm

GAS FUELS RESOURCE CENTER

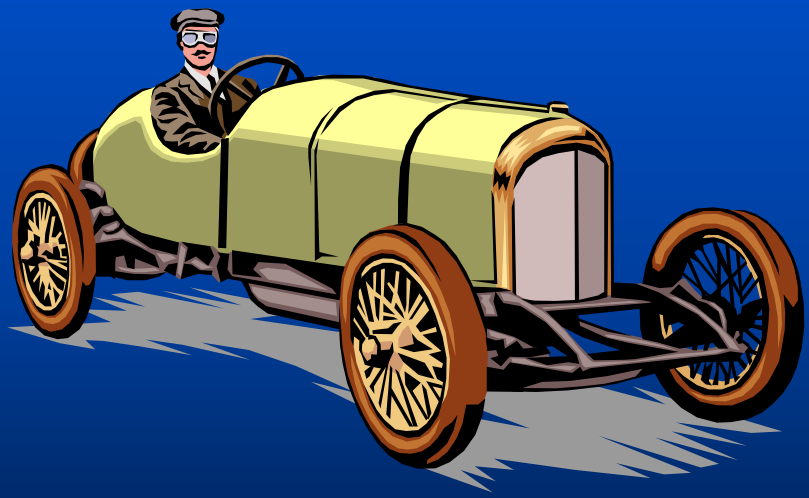
CNG 101

An Introduction to Compressed Natural Gas

Version 0.5

Best viewed at 1024 x 768 resolution

GAS FUELS RESOURCE CENTER



History of CNG Vehicles

Early Natural Gas Vehicles used low pressure natural gas stored in bladders. These vehicles would be unable to carry sufficient fuel for today's applications.

Low Pressure Storage
– Circa 1930.

GAS FUELS RESOURCE CENTER

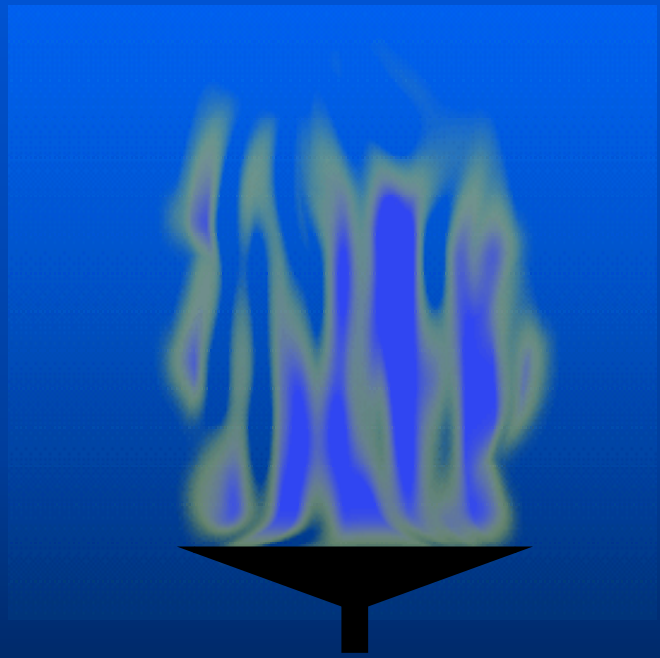
CNG Vehicle Emissions & Other Benefits

Emissions Benefits of Natural Gas

This information is based on a comparison of equivalent technology engines and emission control equipment.

- ✓ Lower Nitrogen Oxide (NO_x) emissions than diesel.
- ✓ Lower Particulate emissions than diesel.
- ✓ Lower Sulfur Dioxide (SO_2) emissions than diesel.
- ✓ Lower Carbon Dioxide (CO_2) emissions than diesel. (In some cases)

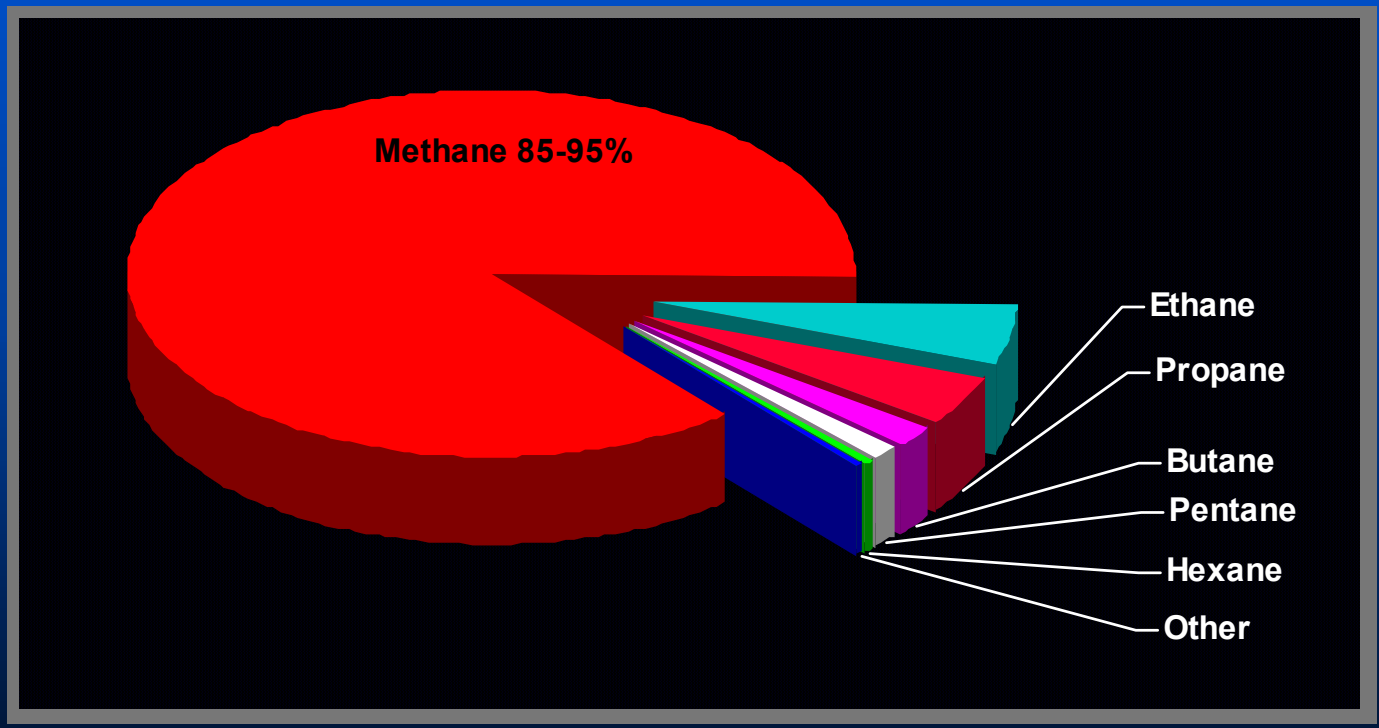
GAS FUELS RESOURCE CENTER



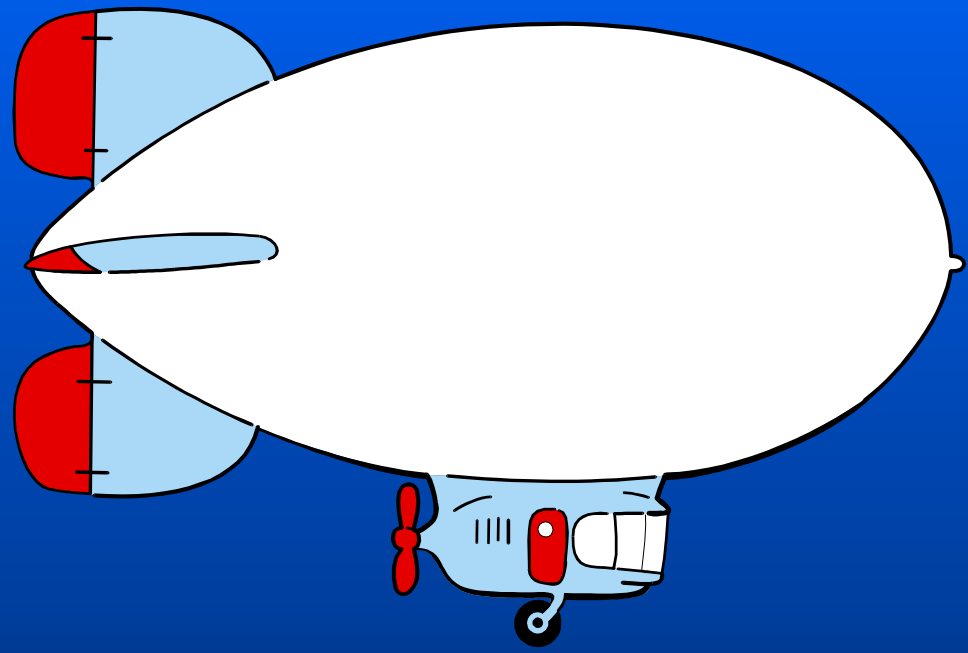
Properties and Fundamentals of Natural Gas

Natural Gas Composition

In the ground, natural gas contains a wide range of compounds. During well-head cleaning and processing, gas quality is improved to pipeline standards. Gas in the pipeline has a range of acceptable compositions. Typical pipeline gas would be as shown.



Natural Gas Density

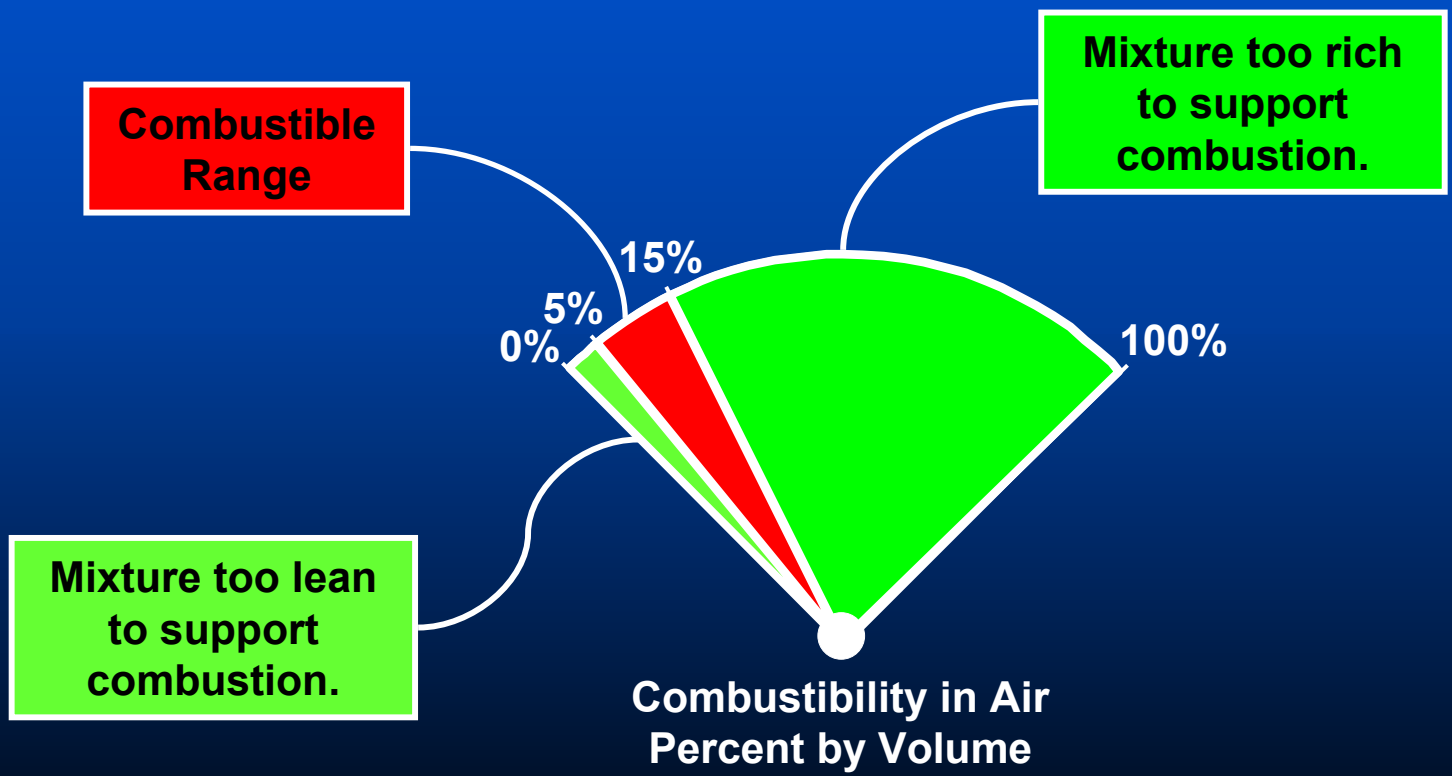


At atmospheric pressure and temperature, natural gas is lighter than air. The density of natural gas is 55% – 65% that of air.

Natural Gas Flammability Limits

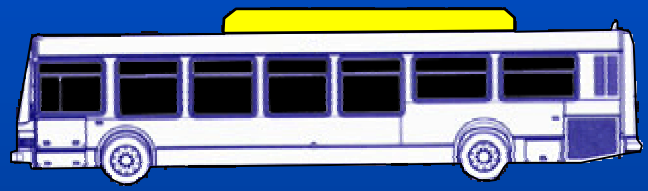
5% concentration in air is known as the Lower Flammability Limit (LFL) or the Lower Explosive Limit (LEL).

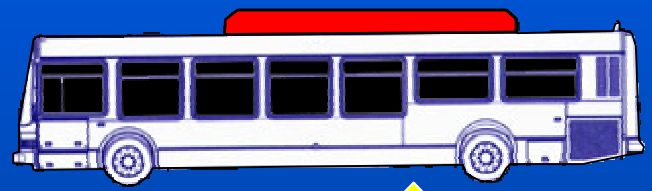
15% concentration in air is known as the Upper Flammability Limit (UFL) or the Upper Explosive Limit (UEL).



The illustration below shows the effect on the pressure in the vehicle cylinders related to the changing temperature of the gas. The total mass in the tanks is constant with changing temperatures and pressures.

3000 psig @ 70° F





Pressure in cylinders is 3400 psig at 100° F.

Pressure in cylinders is 3000 psig at 70° F. (Baseline Condition)

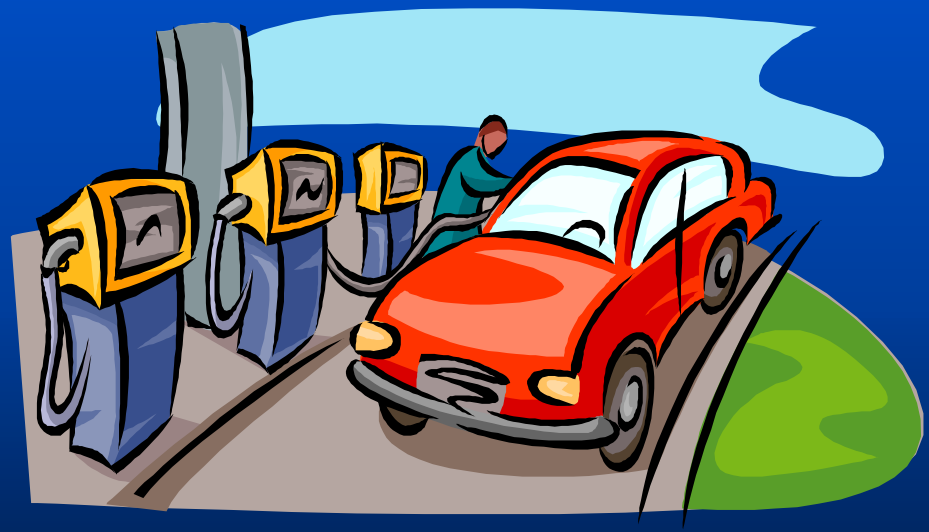
Pressure in cylinders is 2100 psig at 0° F.

This example is based on the 3000 psig @ 70° F fill standard.

GAS FUELS RESOURCE CENTER

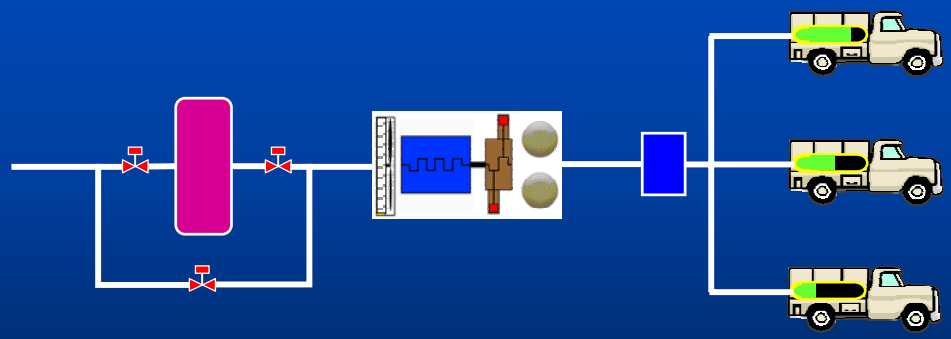
Components of a CNG vehicle

GAS FUELS RESOURCE CENTER



Types of CNG Stations

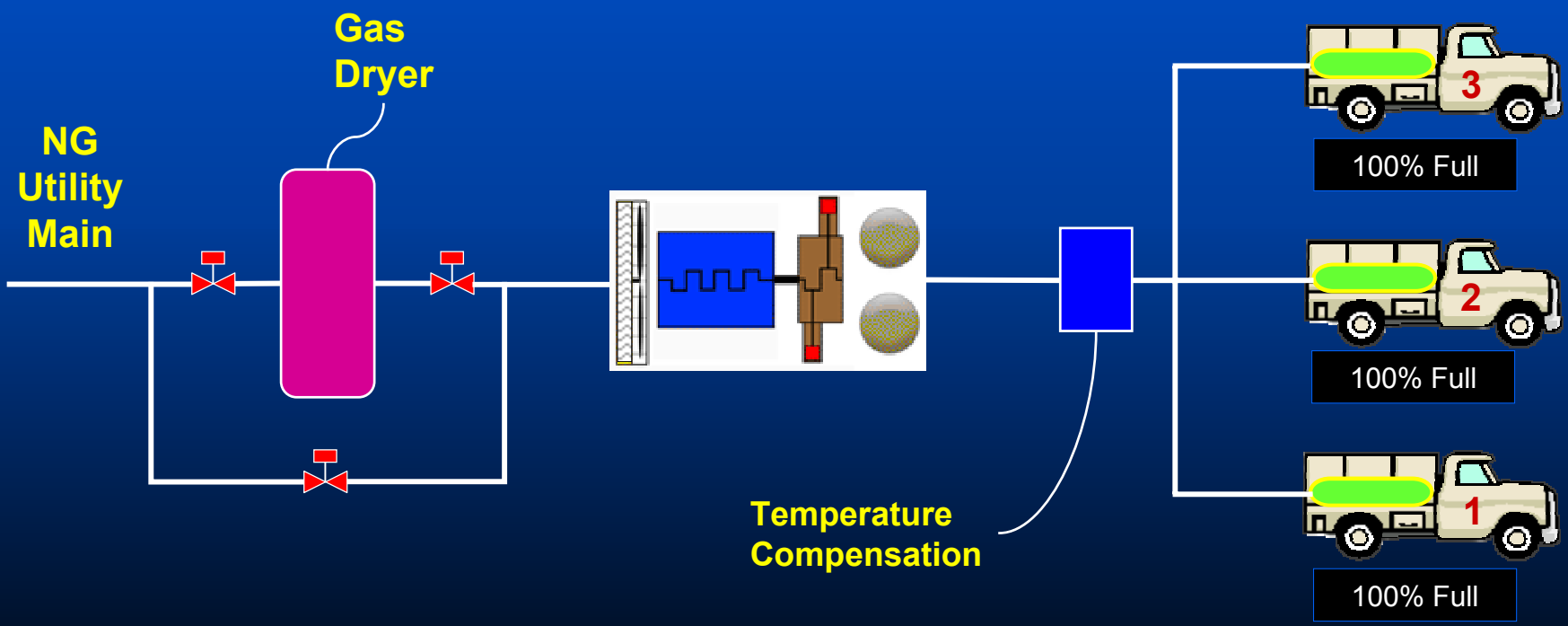
GAS FUELS RESOURCE CENTER



Time Fill

Time Fill Station Simulation

When the temperature compensation system determines that all vehicles are full, the compressor shuts down. Flow terminates. (▼)



Time Fill Using Fueling Appliances

Courtesy FuelMaker

Fueling appliances are used in a wide variety of applications both as time fill (direct fill from unit), or with a small cascade storage to allow limited fast filling.

Commercial applications fuel 1-2 vehicles over an 8 hour period. This model has approximately 2 scfm flow.

Cascade Installations

There are several hundred public access CNG fueling stations across North America. The majority of these stations utilize a Cascade Fast-Fill system.

Courtesy GreenField

Courtesy ANGI

Buffer Installations

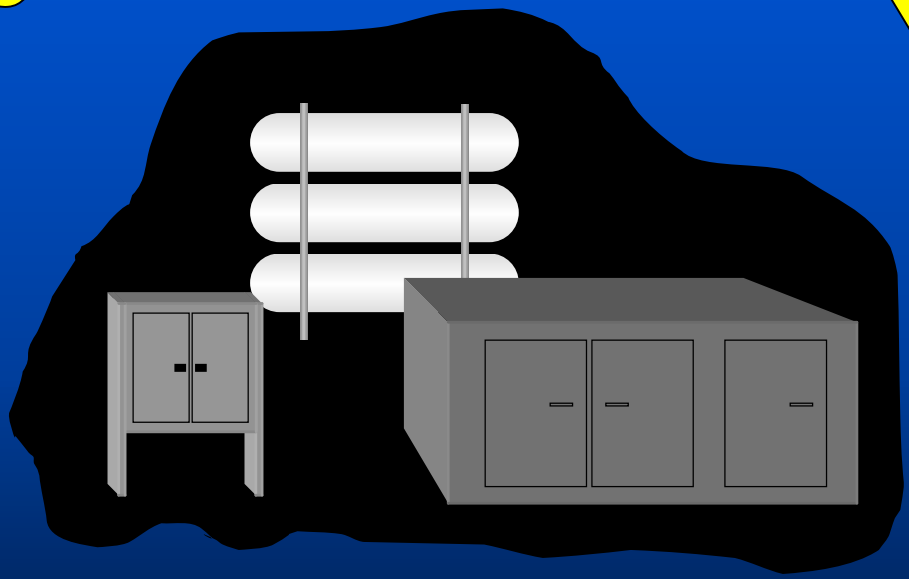
Courtesy ANGI

Large state-of-the-art Buffer Fast-Fill Station, Atlanta Georgia.

Four 1000 scfm compressors, 70,000 scf Buffer capacity, five fast fill hoses. Installation sized for 200 transit bus fleet.

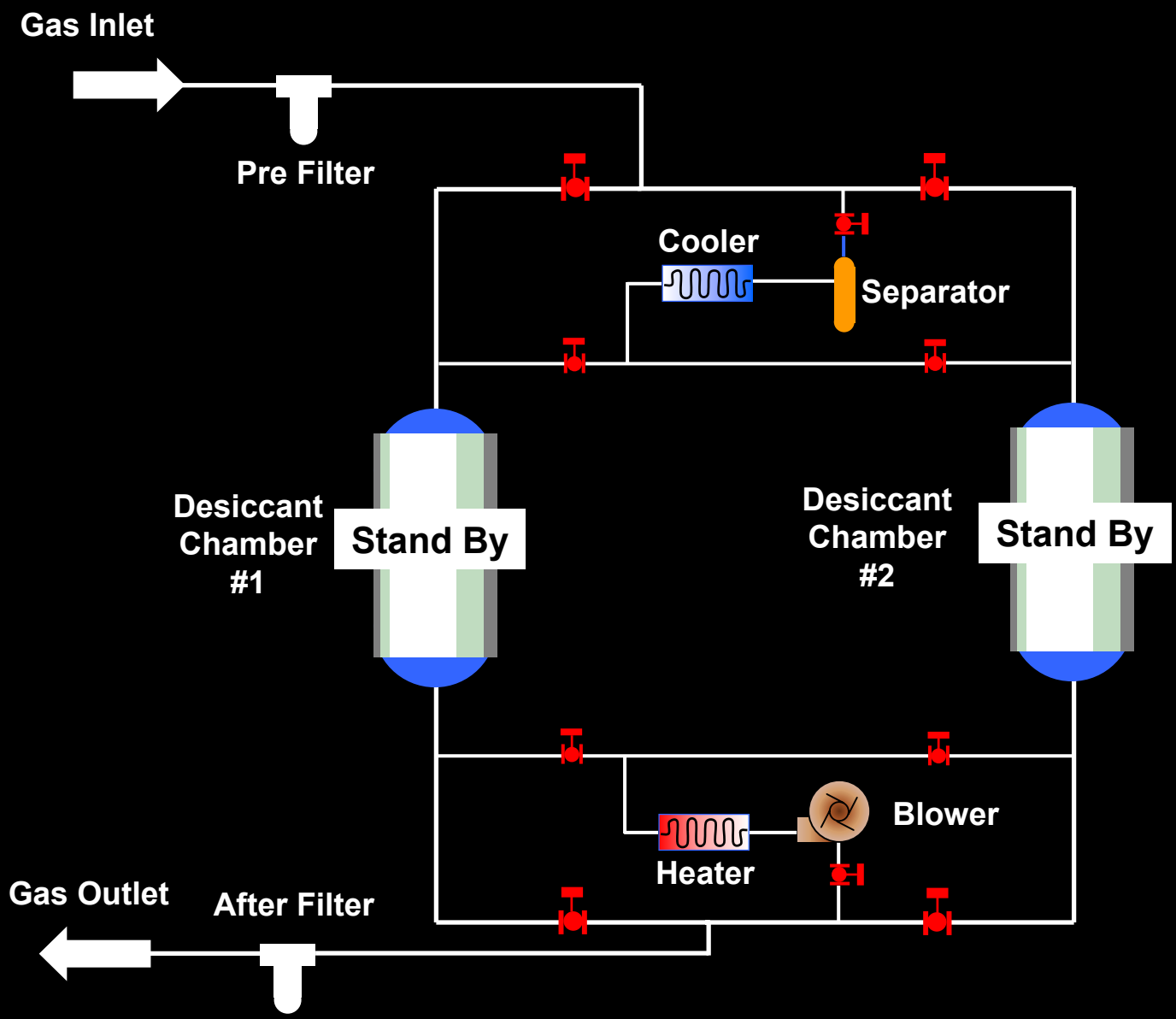
L/CNG Installations

GAS FUELS RESOURCE CENTER



Station Components

Gas Dryer in Stand By



CNG Dryers

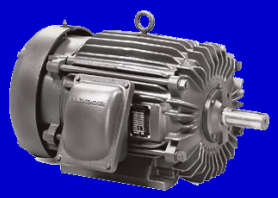
Courtesy Xebec Inc.

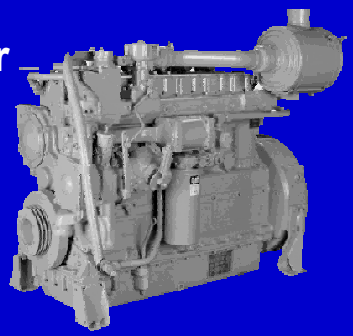
Twin Tower Automatic Regeneration Dryer

This Dryer operates as described in the preceding slides. This configuration is often used in large stations or where moisture content is high.

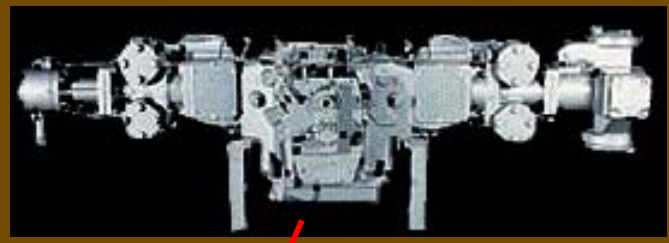
CNG Compressor Main Equipment

Natural Gas
Engine or
Electric Motor

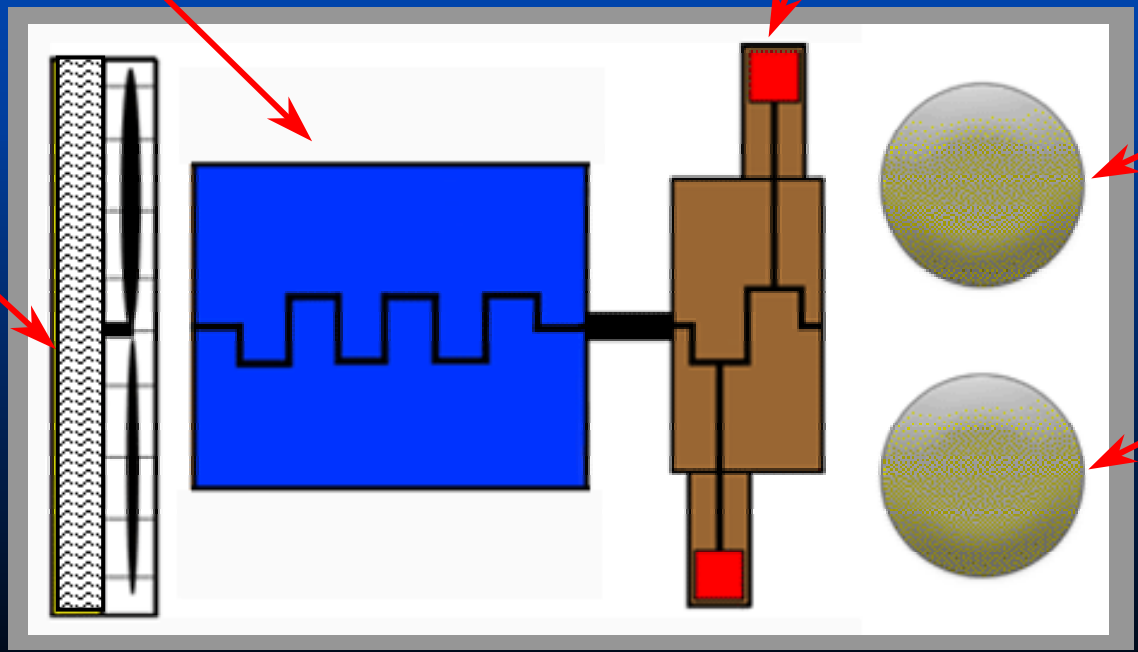


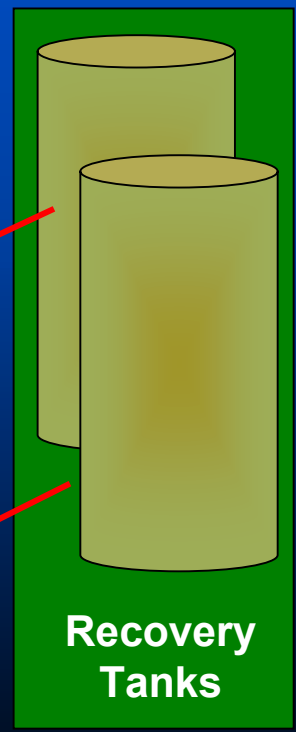


CNG Compressor



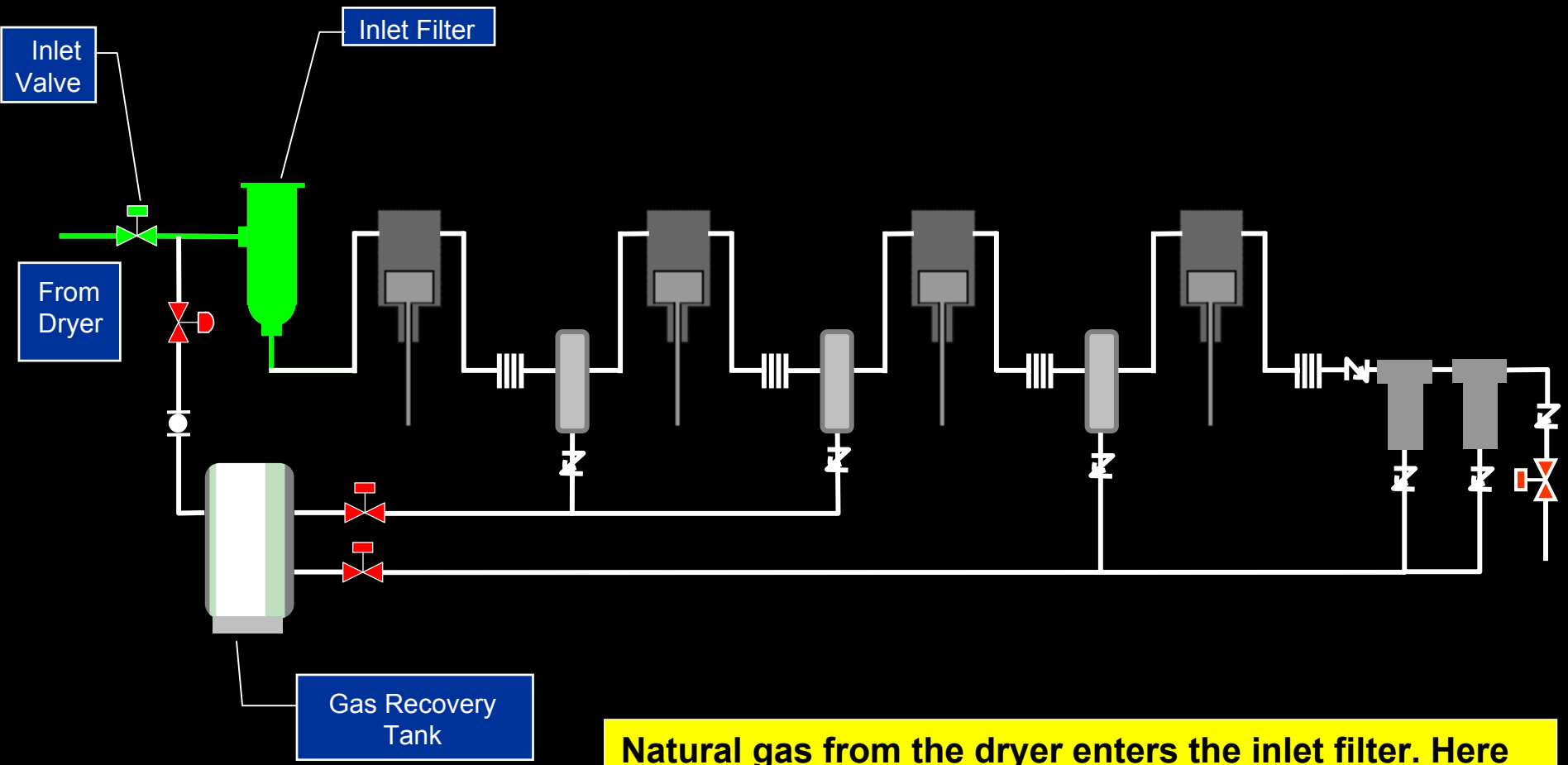
Compressor &
Engine Cooler





Recovery
Tanks

Simplified Compressor Flow Schematic



Natural gas from the dryer enters the inlet filter. Here the gas is cleaned of any particulate. (▼ - cursor down for animation)

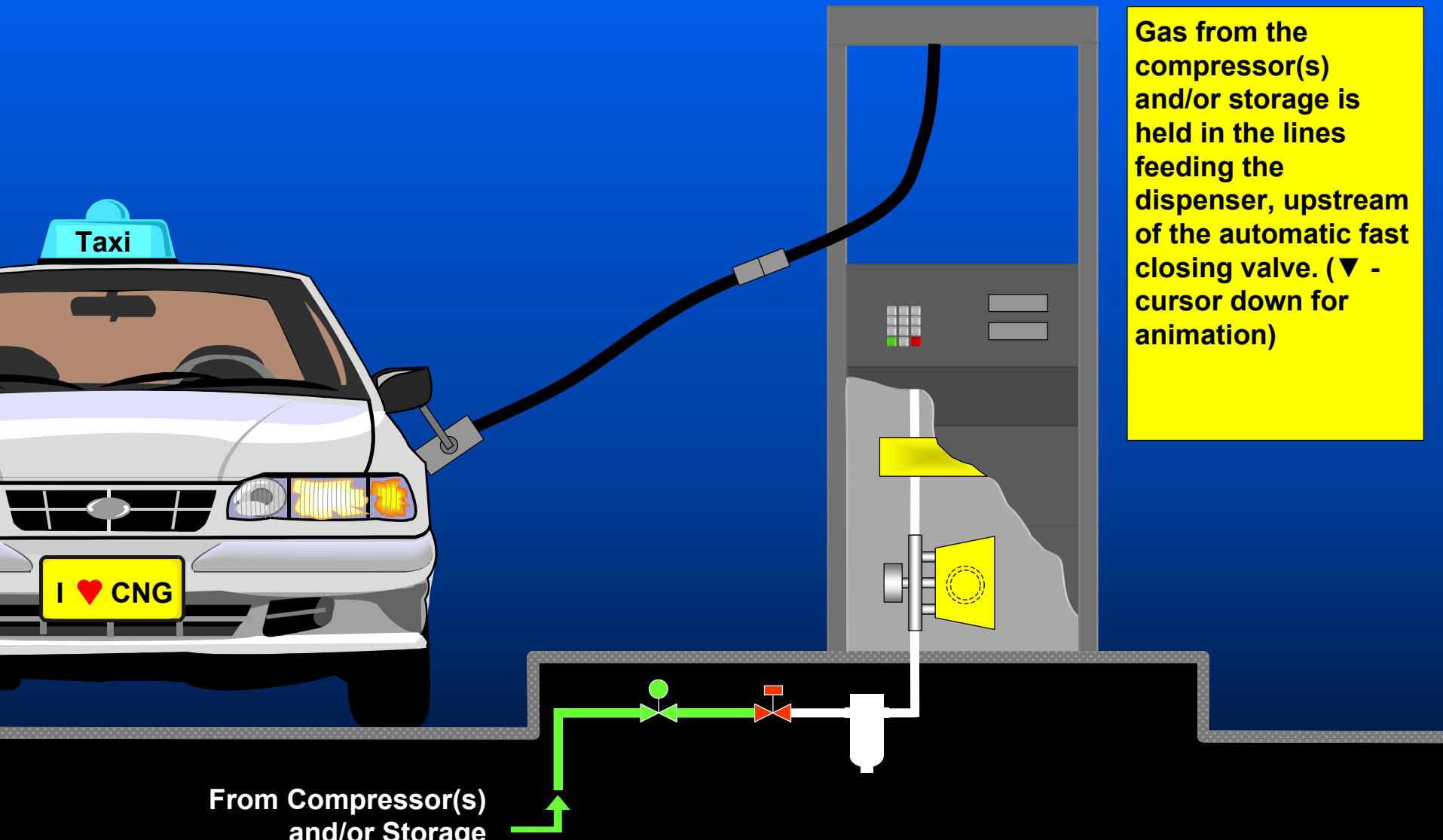
Small Duplex Compressor Package

Courtesy Hurricane

Storage Cylinders

ASME storage tubes rated at 5,500 psi design pressure and approximately 10,000 scf capacity / cylinder.

CNG Dispenser Flow Schematic



Gas from the compressor(s) and/or storage is held in the lines feeding the dispenser, upstream of the automatic fast closing valve. (▼ - cursor down for animation)

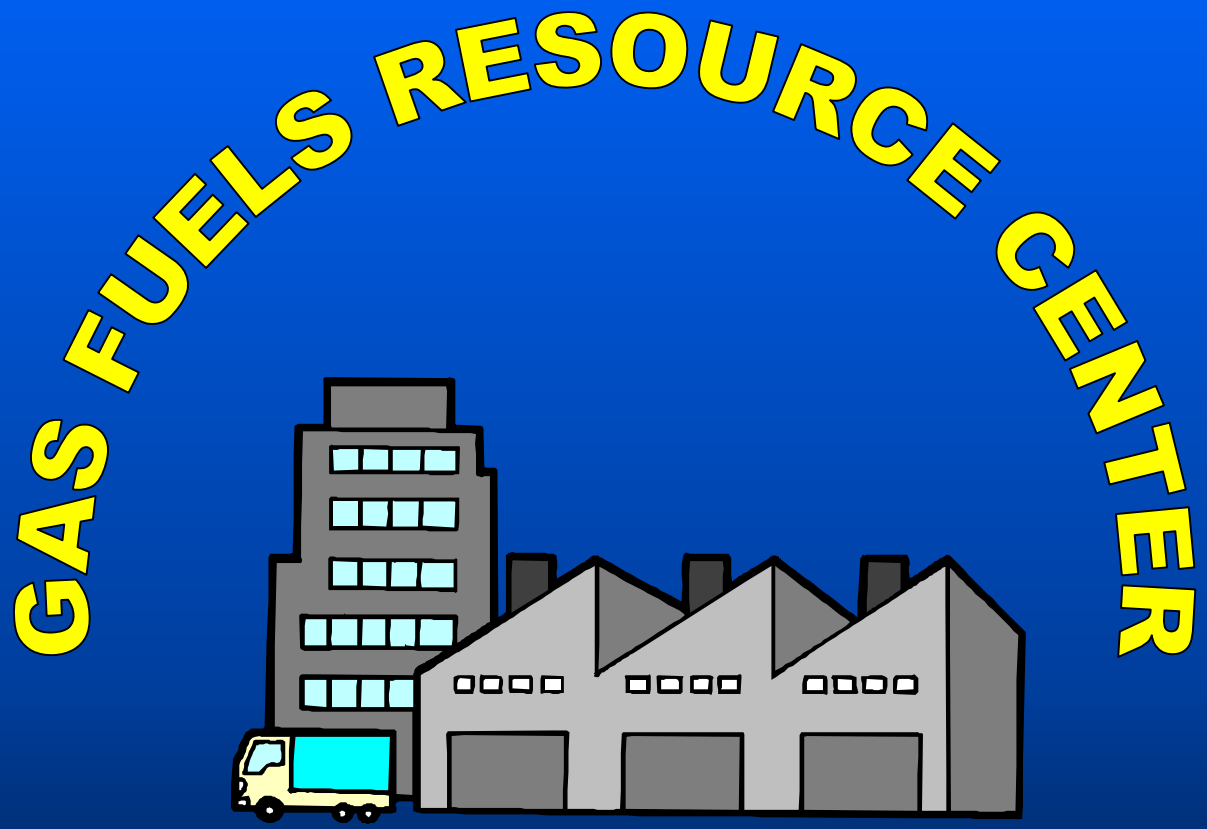
Light Duty Vehicle Dispensers

200 scfm Natural Gas Engine driven Compressor

Three 10,000 scf Cascade storage tubes (total 30,000 scf)

2 dual hose Cascade sequencing CNG Dispensers

Courtesy Greenfield



Vehicle and Engine Manufacturers

JOHN DEERE

Photos are courtesy of
Deere & Company

Natural Gas
6081H, 250 HP

Natural Gas
6068H, 225HP

Natural Gas
6081H, 280 HP

Marathon Technical Services

GAS FUELS RESOURCE CENTER

Test Your Knowledge

Note: Macros must be running for this section to work properly

Test Your Knowledge

The Lower Flammability Limit of natural gas is 15%

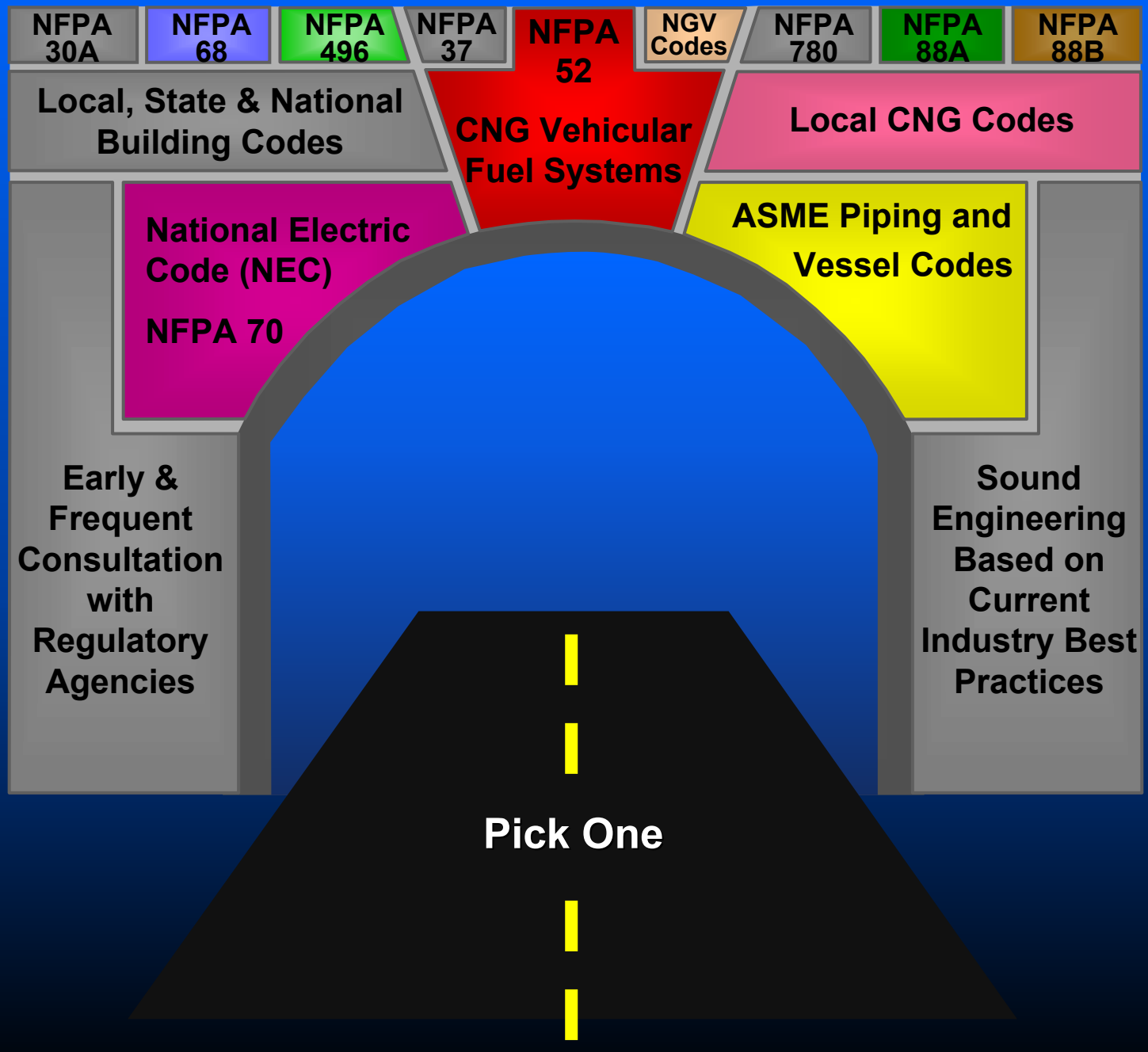
- True
- False

Reset

GAS FUELS RESOURCE CENTER

CNG 201

CNG Code Reference Guide
Version 0.1


NFPA 30A
NFPA 68
NFPA 496
NFPA 37
NFPA 52
NGV Codes
NFPA 780
NFPA 88A
NFPA 88B
Local, State & National Building Codes
CNG Vehicular Fuel Systems
Local CNG Codes
National Electric Code (NEC)
NFPA 70
ASME Piping and Vessel Codes
Early & Frequent Consultation with Regulatory Agencies
Sound Engineering Based on Current Industry Best Practices
Pick One

GAS FUELS RESOURCE CENTER

NFPA 52 - 1998
CNG Vehicular Fuels System

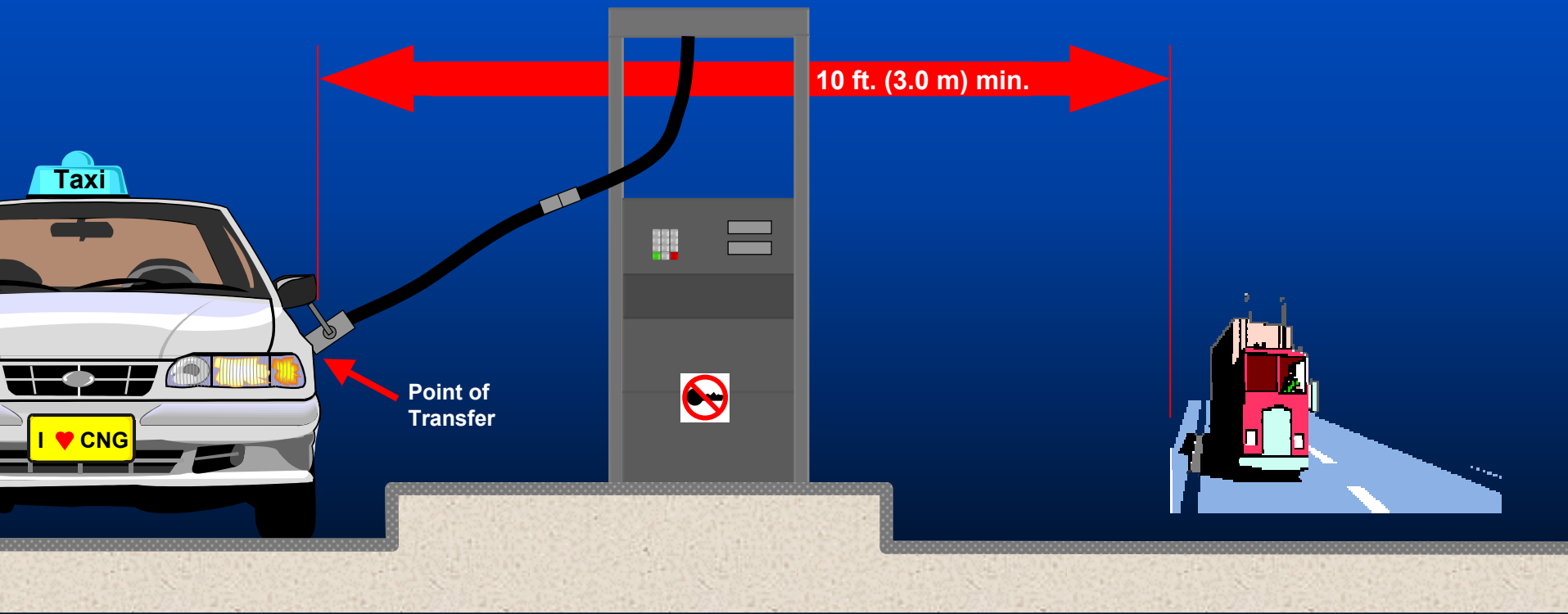
This presentation includes only sections relevant to CNG station greater than 10 SCFM. Sections related to fueling appliances and vehicles have been omitted.

2-5-2.2 Pressure relief valves for CNG service shall not be fitted with lifting devices. The adjustment, if external, shall be provided with a means for sealing the adjustment to prevent tampering. If at any time it is necessary to break such a seal, the valve shall be removed from service until it has been reset and sealed. Only the manufacturer or other companies having competent personnel and facilities for the repair, adjustment, and testing of such valves shall make adjustments. The organization making such adjustment shall attach a permanent tag with the setting, capacity, and date. Pressure relief valves protecting ASME pressure vessels shall be repaired, adjusted, and tested in accordance with the ASME *Boiler and Pressure Vessel Code*.

Set & sealed by National Board certified shop

2-8-1	Pipe, tubing, fittings, gaskets, and packing material shall be compatible with the fuel under the service conditions.	
2-8-2	Pipe, tubing, fittings, and other piping components shall be capable of withstanding a hydrostatic test of at least four times the rated service pressure **Author's Comment : There is some inconsistency in the industry in the interpretation of "service pressure". The definition in NFPA 52 relates to pressures on vehicles and does not directly apply to station pressure calculations. The conservative interpretation in the industry would be as follows:** **Service Pressure = Relief Valve setting** **Operating Pressure = Maximum normal gas pressure (usually < 90% relief valve setting)** **Maximum Allowable Operating Pressure (MAOP) = Service Pressure**	**Related Information** Temperature Compensation Fill Pressure Operating Pressure Settled Pressure Service Pressure
2-8-3	Natural gas piping shall be fabricated and tested in accordance with ANSI/ASME B31.3, *Chemical Plant and Petroleum Refinery Piping.*	**Related Information** ASME B31.3

4-4.2.8	During outdoor fueling operations, the point of transfer shall be located at least 10 ft. (3.0 m) from any important building, mobile home, public sidewalk, highway, street, or road and at least 3 ft. (1.0 m) from storage containers. *Exception: The point of transfer shall be permitted to be located at a lesser distance from buildings or walls constructed of concrete or masonry materials or of other material having a fire resistance rating of at least 2 hours, but at least 10 ft. (3.0 m) from any buildings openings.*	**Related Information** Point of Transfer



4-10.2	Pressure relief valves shall be tested at least every 5 years.

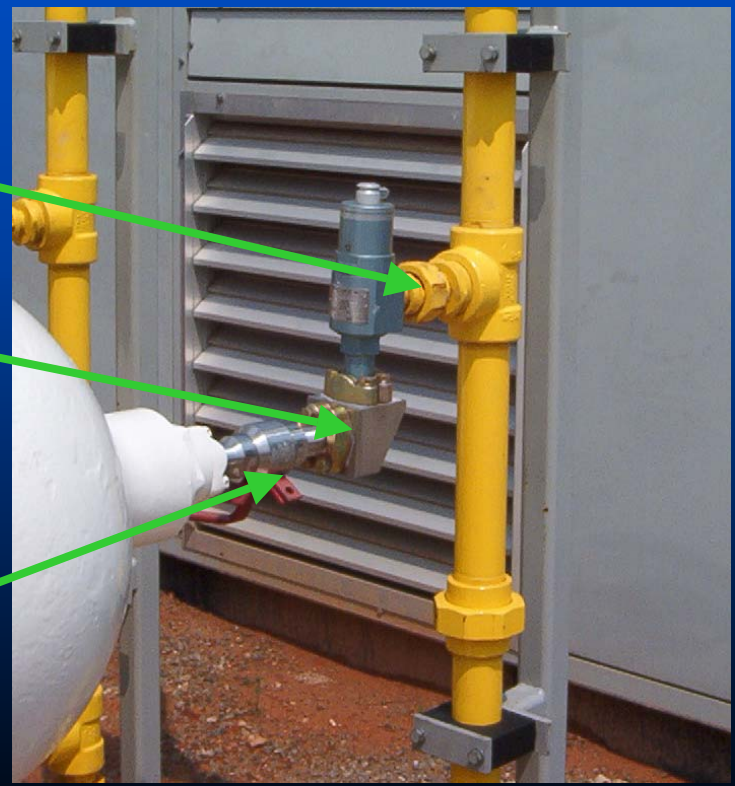
Author's Comment : Relief valves must be installed for ease of removal and reinstallation. This can be accomplished by providing flanged, O-ring, or compression position-able fittings on the inlet; and pipe unions or position-able fittings on the outlet.

Relief valves on storage vessels and other large vessels should include lockable isolation valve on the inlet side – valve to be locked in the open position during normal operation.

Pipe union on outlet

O-ring flanged fitting on inlet

Lockable isolation valve on inlet



GAS FUELS RESOURCE CENTER

NFPA 70 - 2002
National Electric Code (NEC)

GAS FUELS RESOURCE CENTER

ASME Piping and Vessel Codes

GAS FUELS RESOURCE CENTER

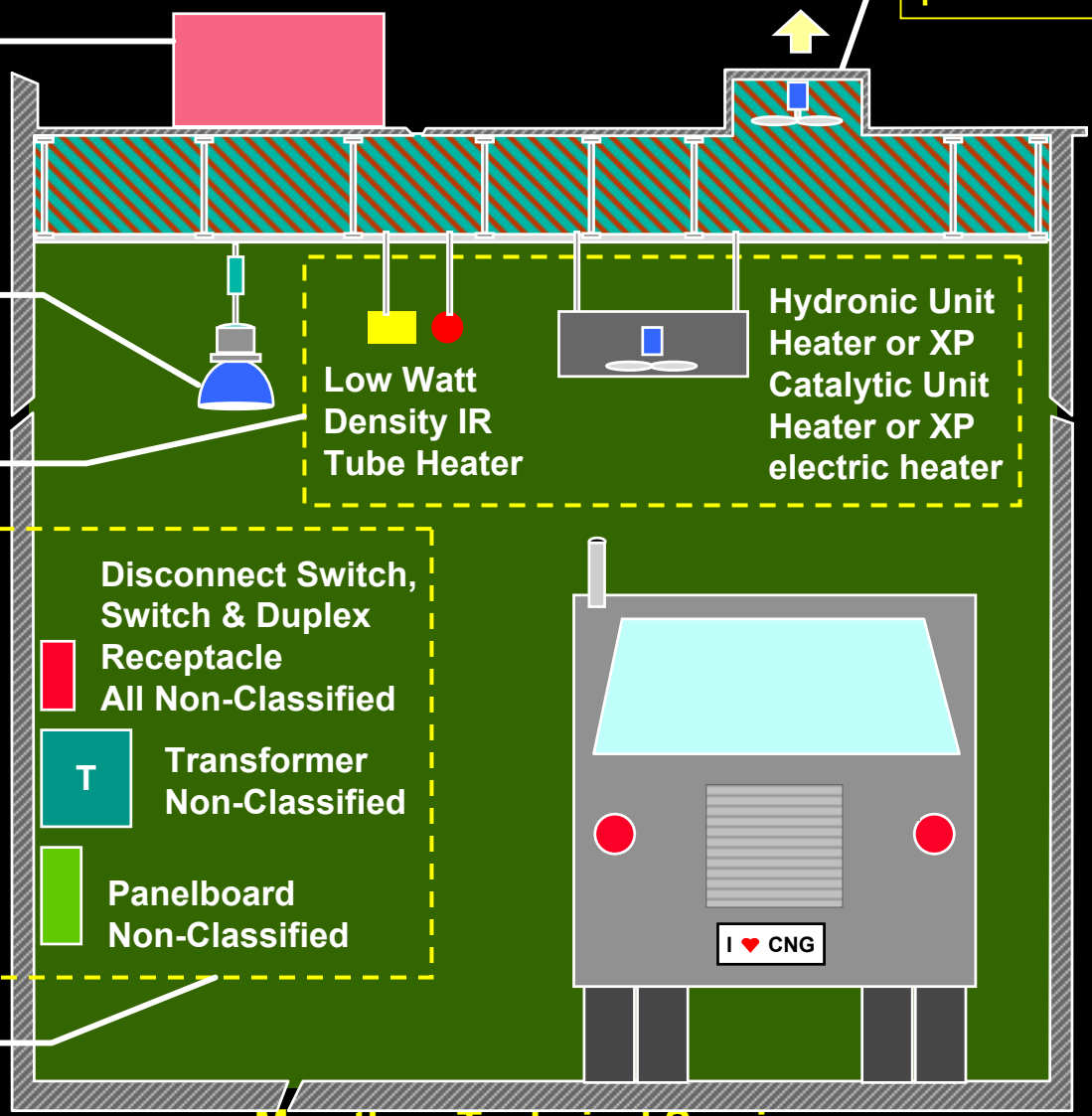
NFPA 68 - 1998
Venting of Deflagrations

GAS FUELS RESOURCE CENTER

NFPA 88A - 1998
Parking Structures

NFPA 88A Parking Structures

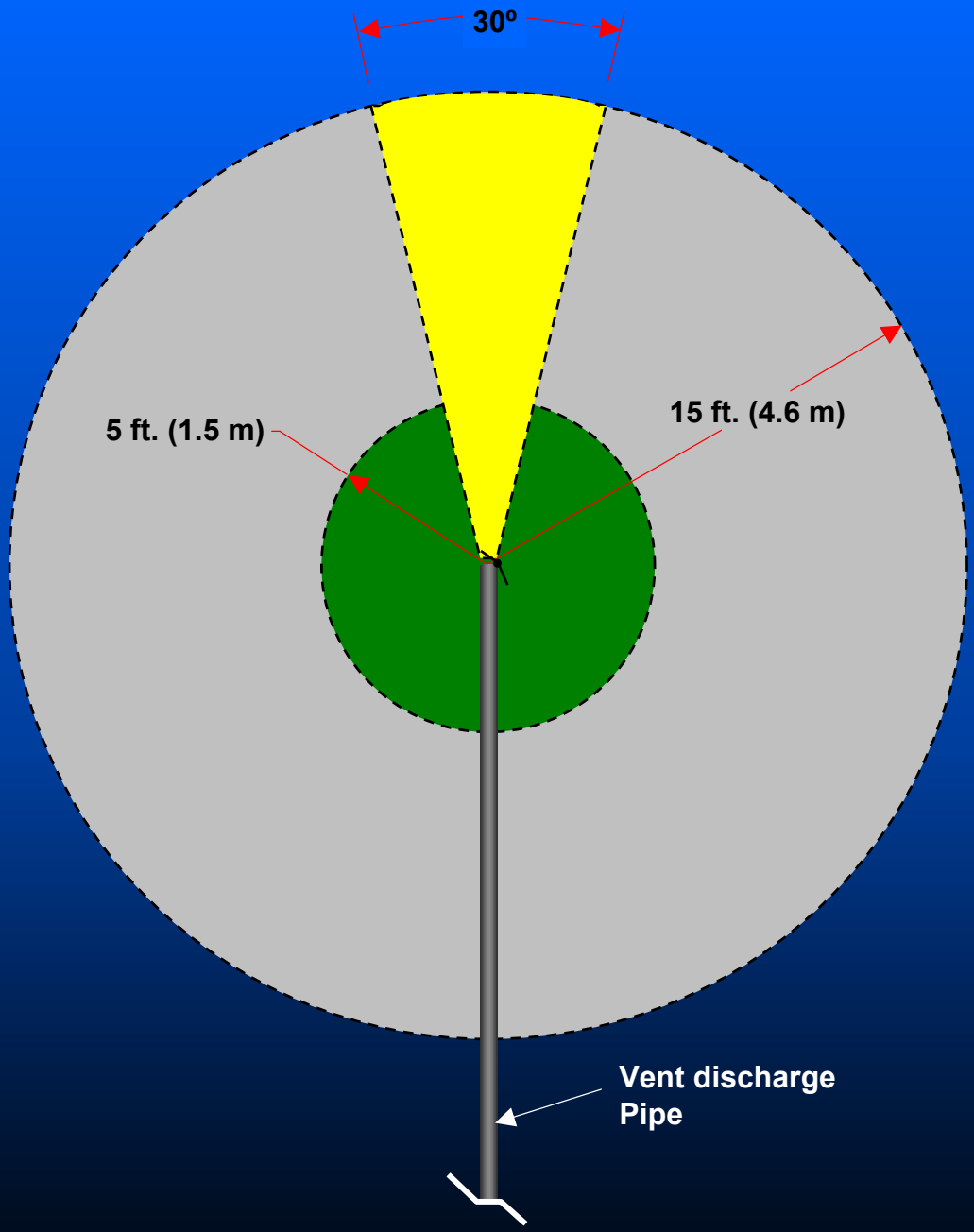
Mechanical ventilation minimum of 1.0 cfm per sq ft^2 of floor area.



GAS FUELS RESOURCE CENTER

NFPA 88B - 1997
Repair Garages

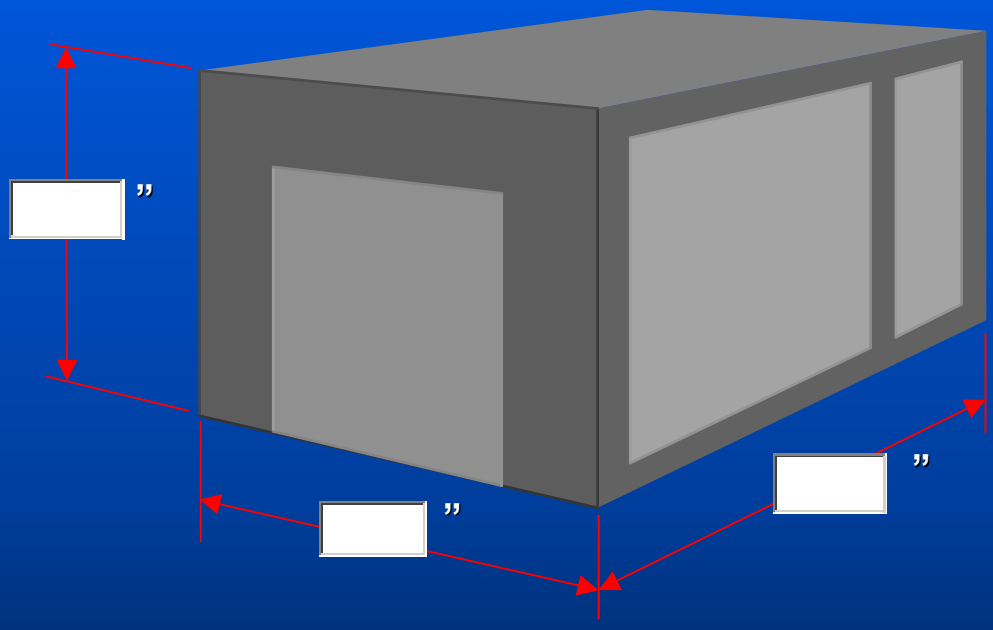
Portions of this document pertaining to Repair Garages are now included in NFPA 30A – 2000.



CLASS 1, DIVISION 2

CLASS 1, DIVISION 1

CLASS 1, DIVISION 1



Note: Dimensions must be inches

Maximum 1.5	P_{red} :	
Internal Surface Area (Ft ^{2})	A_s :	
Fuel Constant	(C) :	

Please select a Fuel Constant

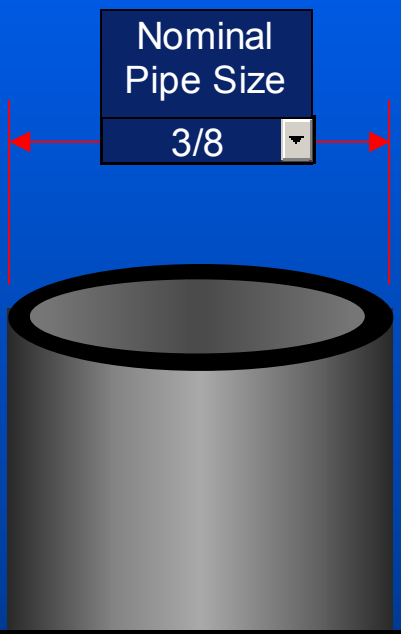
Vent Area (Ft ^{2}) A_v =

This tool should not be used for design purposes. Users should consult with all of the requirements of applicable codes and ensure that their design complies with these.

Calculate Reset

ANSI B31.3 Section 304 Chemical Plant and Petroleum Refinery Piping

To calculate the minimum wall thickness based on a known pressure requirement.



P = 2000 psig

D = .675 inches

E = 1.0 * Seamless pipe

Y = 0.4

S = psi

t =

Threading
- [ ] Yes
- [x] No

Design Temperature
- [ ] 200 F
- [ ] 300 F
- [ ] 350 F

Pick First

- (•) A106 Grade B Pipe
- ( ) SA213, TP304 Tubing
- ( ) SA213, TP304L Tubing

This tool should not be used for design purposes. Users should consult with all of the requirements of applicable codes and ensure that their design complies with these.

For tubing, consult with tube fitting manufacturer to confirm that tube wall thickness falls within acceptable range.

Calculate

Nominal Wall Thickness inches

Assuming a negative 10 percent tolerance for tubing and negative 12 ½ percent for piping.

Vehicle to Vehicle CNG Transfer Procedure

"Best Practices" # CNG - 01

11. Open the fueling door of the donor vehicle and close the main shut-off valve. Remove the dust cap on the NGV-1 vehicle fueling receptacle and connect the defueling nozzle.

DONOR VEHICLE

If personnel experience difficulty connecting the defueling nozzle to the NGV-1 receptacle, ensure that the lever is fully retracted.

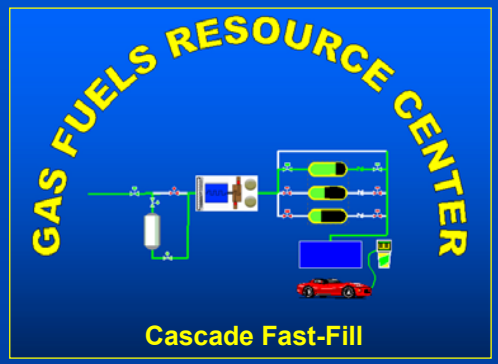
GAS FUELS RESOURCE CENTER

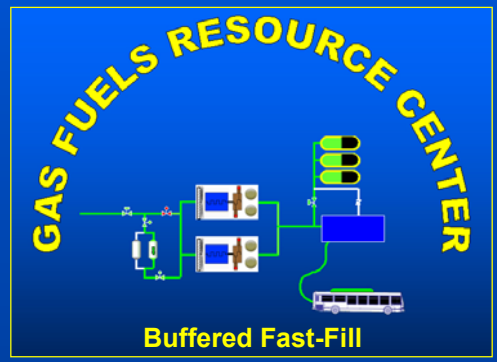
CNG Station Best Practice 2.0

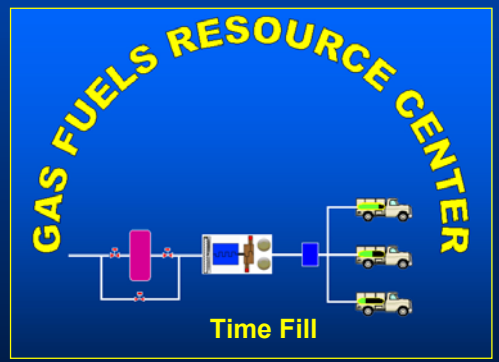
CNG Station Sizing & Selection

Station Equipment Sizing

Mouse Click on a Station Type







See CNG 101 for detailed information on each station type.

We wish to thank

GTI / IWG / DOE

and the

NGV TECHNOLOGY FORUM